FORM PTO-1390 (REV. 11-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY 'S DOCKET NUMBER: A01205US (98148.19)

U.S APPLICATION NO (If known, see 37 CFR 1 5): 09/913905

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/GB00/00526	17 February 2000 (17.02.00)	17 February 1999 (17.02.99)

TITLE OF INVENTION: "ROTATING SURFACE OF REVOLUTION REACTOR WITH TEMPERATURE CONTROL MECHANISMS"

APPLICANT(S) FOR DO/EO/US: RAMSHAW, Colin; JACHUCK, Roshan, Jeet, Jee

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U S.C 371
3. [ ] This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. [ ] The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is attached hereto (required only if not communicated by the International Bureau).
   b. [ ] has been communicated by the International Bureau.
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US)
6. [ ] An English language translation of the International Application as filed (35 U.S.C 371(c)(2)).
   a. [ ] is attached hereto.
   b. [ ] has been previously submitted under 35 U.S.C. 154(d)(4).
7. [ ] Amendments to the claims of the International Aplication under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are attached hereto (required only if not communicated by the International Bureau).
   b [ ] have been communicated by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired
   d [ ] have not been made and will not be made.
8. [ ] An English language translation of the amendments to the claims under PCT Article 19 (35 U.S C 371 (c)(3))
9. [ ] An oath or declaration of the inventor(s) (35 U.S C. 371(c)(4)).
10. [ ] An English lanugage translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3 28 and 3 31 is included
13. [ ] A FIRST preliminary amendment.
14. [ ] A SECOND or SUBSEQUENT preliminary amendment.
15. [ ] A substitute specification.
16. [ ] A change of power of attorney and/or address letter.
17. [ ] A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1 821 - 1.825
18. [X] A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. [ ] A second copy of the English language translation of the international application under 35 U S C 154(d)(4).
20. [ ] Other items or information:

PCT/PTO 17 AUG 2001

U.S. APPLICATION NO (if known, see 37 CFR 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
09/913905	PCT/GB00/00526	A01205US (98148.19)

21. ☐ The following fees are submitted:	CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO **$1000.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO **$860.00**		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO **$710.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) **$690.00**		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 1,000	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$ 130	

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	- 20 =		x **$18.00**	$
Independent claims	- 3 =		x **$80.00**	$
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$270.00**	$

TOTAL OF ABOVE CALCULATIONS =	$ 1,130	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2. +	$ 565	
SUBTOTAL =	$ 565	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).	$	
TOTAL NATIONAL FEE =	$ 565	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +	$	
TOTAL FEES ENCLOSED =	$ 565	
	Amount to be refunded:	$
	charged:	$

a. ☒ A check in the amount of $ 565 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. _____ in the amount of $ _____ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☐ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. _____. A duplicate copy of this sheet is enclosed.

d. ☐ Fees are to be charged to a credit card. **WARNING:** Information on this form may become public. **Credit card information should not be included on this form.** Provide credit card information and authorization on PTO-2038.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO **Seth M. Nehrbass**

GARVEY, SMITH, NEHRBASS & DOODY, L.L.C.
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US

PTO Customer Number 22920

SIGNATURE

BRETT A. NORTH
NAME

42,040
REGISTRATION NUMBER

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANTS: RAMSHAW, Colin and
JACHUCK, Roshan, Jeet, Jee

ASSIGNEE: Protensive Limited (A UK Company)

U.S. APPLICATION NO.: 09/913,905

INTERNATIONAL APPL. NO.: PCT/GB00/00526 I.A. FILING DATE: 02-17-2000

FOR: "ROTATING SURFACE OF REVOLUTION REACTOR WITH TEMPERATURE CONTROL MECHANISMS"

ATTORNEY DOCKET NO.: A01205US (98148.19)

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PRELIMINARY AMENDMENT AND
RESPONSE TO NOTICE TO FILE MISSING PARTS

Commissioner of Patents
and Trademarks
Washington, D.C. 20231

Sir:

This is an Amendment and Response to the Notice mailed from the U.S. Patent Office on October 19, 2001 in the above-referenced application. A deadline to respond was set to expire two months from the date of the Notice, making a response due by December 19, 2001.

AMENDMENT

Please amend the application as follows:

IN THE CLAIMS:

Please amend the claims to read as follows:

-- 1.(Amended) A reactor apparatus including a hollow support element adapted to be rotatable about an axis, the support element having a first, external reaction surface and a second, internal heat transfer surface and means for applying a heat transfer fluid to the second surface, the

first and second surfaces being in thermal communication with each other and the support element including an internal space bounded on one side by the second surface, characterised in that a plate or membrane is provided inside the hollow support element, the plate or membrane extending substantially over the whole internal space so as to define a first space between the second surface and one side of the plate or membrane and a second space between an opposed side of the plate or membrane and an internal surface of the support element remote from the second surface, but leaving a gap at a periphery of the plate or membrane so as to allow a heat transfer fluid to flow between the first and second spaces.

2.(Amended) A reactor as claimed in claim 1, wherein the means for applying a heat transfer fluid comprises a fluid feed to an axial portion of the first space.

3.(Amended) A reactor as claimed in claim 2, wherein the means for applying a heat transfer fluid comprises a feed tube passing along a hollow drive shaft connected to an axial portion of the support element, the feed tube being adapted to supply heat transfer fluid to the first space.

4.(Amended) A reactor as claimed in claim 3, wherein a heat transfer fluid flow path is defined by the feed tube, the first space, the peripheral gap, the second space and a space provided between an external surface of the feed tube and an internal surface of the hollow drive shaft.

5.(Amended) A reactor as claimed in claim 1, wherein the opposed side of the plate or membrane is provided with vanes, fins or other projections.

6.(Amended) A reactor as claimed in claim 1, wherein the opposed side of the plate or membrane is provided with a mesh or gauze or foam.

7.(Amended) A reactor as claimed in claim 5, wherein the vanes, fins or other projections are radially oriented with respect to the axis of rotation.

8.(Amended) A reactor as claimed claim 1, wherein the second surface is provided with a thermally conductive mesh, grid, corrugations or other projections which serve to increase a heat transfer area of the second surface.

9.(Amended) A reactor apparatus including a support element adapted to be rotatable about an axis, the support element having generally opposed first and second surfaces, feed means for supplying at least one reactant to the first surface of the support element, collector means for collecting product from the first surface of the support element and means for applying a heat

transfer fluid to the second surface, characterised in that the support element has a generally circular outer perimeter provided with a groove or indent thereabout and a circumferential baffle is fitted about the perimeter of the support element so as to project into the groove or indent while still allowing the support element to rotate freely, the circumferential baffle serving to keep separate reactant and heat transfer fluid which are thrown respectively from the first and second surfaces during operation of the reactor.

10.(Amended) A reactor apparatus including a support element adapted to be rotatable about an axis, the support element having generally opposed first and second surfaces, feed means for supplying at least one reactant to the first surface of the support element, collector means for collecting product from the first surface of the support element and means for applying a heat transfer fluid to the second surface, characterised in that the second surface includes an axially located undercut trough into which the heat transfer fluid is supplied during operation of the reactor.

11.(Amended) A reactor as claimed in claim 1, wherein there is further provided a rotary impeller or fan mounted close to the first surface and operable to generate a gaseous flow from a periphery of the surface towards a central region thereof, this flow being counter-current to a flow of reactant on the first surface.- -

Please add the following new claims:

--12.(New) A reactor as claimed in claim 9, wherein there is further provided a rotary impeller or fan mounted close to the first surface and operable to generate a gaseous flow from a periphery of the surface towards a central region thereof, this flow being counter-current to a flow of reactant on the first surface.

13.(New) A reactor as claimed in claim 10, wherein there is further provided a rotary impeller or fan mounted close to the first surface and operable to generate a gaseous flow from a periphery of the surface towards a central region thereof, this flow being counter-current to a flow of reactant on the first surface.--

REMARKS

The claims have been amended to eliminate multiple dependencies. Two sets of claims are included, one set showing the changes made in this response (attached) and one clean set (set out above). No new matter has been added to the application.

A declaration has been enclosed. No Additional claims fees have been included as the multiple dependencies have been removed by preliminary amendment.

Applicant respectfully submits that the application is in condition for allowance. A Notice of Allowance is hereby respectfully requested.

Should the Examiner feel that a telephone conference would advance the prosecution of this application, he is encouraged to contact the undersigned at the telephone number listed below.

Applicant respectfully petitions the Commissioner for any extension of time necessary to render this paper timely.

Please charge any fees due or credit any overpayment to Deposit Account No. 50-0694.

Respectfully submitted,

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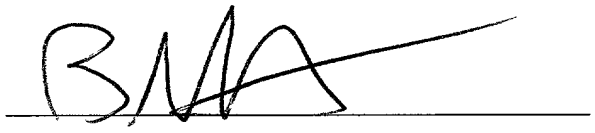
CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as First Class Mail in an envelope addressed to: Commissioner of Patents and Trademarks, Washington, D.C. 20231, on this 18 day of December, 2001.



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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICANTS: RAMSHAW, Colin and
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U.S. APPLICATION NO.: 09/913,905

INTERNATIONAL APPL. NO.: PCT/GB00/00526 I.A. FILING DATE: 02-17-2000

FOR: "ROTATING SURFACE OF REVOLUTION REACTOR WITH TEMPERATURE CONTROL MECHANISMS"

ATTORNEY DOCKET NO.: A01205US (98148.19)

* * * * * * * * * * * * * * *

Copy of Amendments Showing Changes

The application has been amended in the foregoing amendment to read as follows (added matter is underlined and omitted matter is in brackets). To facilitate prosecution all claims have been included, even those not amended:

1.(Amended) A reactor apparatus including a hollow support element [(18)] adapted to be rotatable about an axis [(6)], the support element [(18)] having a first, external reaction surface [(19)] and a second, internal heat transfer surface [(20)] and means [(26)] for applying a heat transfer fluid to the second surface [(20)], the first and second surfaces [(19, 20)] being in thermal communication with each other and the support element [(18)] including an internal space bounded on one side by the second surface [(20)], characterised in that a plate or membrane [(22)] is provided inside the hollow support element [(18)], the plate or membrane [(22)] extending substantially over the whole internal space so as to define a first space [(23)] between the second surface [(20)] and one side of the plate or membrane [(22)] and a second space [(24)] between an opposed side of the plate or membrane [(22)] and an internal surface [(25)] of the support element [(18)] remote from the second surface[(20)], but leaving a gap at a periphery of the plate or membrane [(22)] so as to allow a heat transfer fluid to flow between the first and second spaces [(23, 24)].

2.(Amended) A reactor as claimed in claim 1, wherein the means [(26)] for applying a heat transfer fluid comprises a fluid feed [(26)] to an axial portion of the first space [(23)].

3.(Amended) A reactor as claimed in claim 2, wherein the means [(26)] for applying a heat transfer fluid comprises a feed tube [(26)] passing along a hollow drive shaft [(21)] connected to an axial portion of the support element [(18)], the feed tube [(26)] being adapted to supply heat transfer fluid to the first space [(23)].

4.(Amended) A reactor as claimed in claim 3, wherein a heat transfer fluid flow path is defined by the feed tube [(26)], the first space [(23)], the peripheral gap, the second space [(24)] and a space provided between an external surface of the feed tube [(26)] and an internal surface of the hollow drive shaft[(21)].

5.(Amended) A reactor as claimed in [any preceding] claim 1, wherein the opposed side of the plate or membrane [(22)] is provided with vanes, fins or other projections [(29)].

6.(Amended) A reactor as claimed in [any preceding] claim 1, wherein the opposed side of the plate or membrane [(22)] is provided with a mesh or gauze or foam.

7.(Amended) A reactor as claimed in claim 5, wherein the vanes, fins or other projections [(29)] are radially oriented with respect to the axis of rotation[(6)].

8.(Amended) A reactor as claimed [in any preceding] claim 1, wherein the second surface [(20)] is provided with a thermally conductive mesh, grid, corrugations or other projections [(28)] which serve to increase a heat transfer area of the second surface [(20)].

9.(Amended) A reactor apparatus including a support element [(3)] adapted to be rotatable about an axis [(6)], the support element [(3)] having generally opposed first and second surfaces[(5, 30)], feed means [(4)] for supplying at least one reactant [(15)] to the first surface [(5)] of the support element[(3)], collector means [(32)] for collecting product from the first surface [(5)] of the support element [(3)] and means [(34)] for applying a heat transfer fluid [(35)] to the second surface[(30)], characterised in that the support element [(18)] has a generally circular outer perimeter [(37)] provided with a groove or indent [(36)] thereabout and a circumferential baffle [(32)] is fitted about the perimeter [(37)] of the support element [(3)] so as to project into the groove or indent [(36)] while still allowing the support element [(3)] to rotate freely, the circumferential baffle [(32)] serving

to keep separate reactant [(15)] and heat transfer fluid [(35)] which are thrown respectively from the first and second surfaces [(5, 30)] during operation of the reactor.

10.(Amended) A reactor apparatus including a support element [(3)] adapted to be rotatable about an axis[(6)], the support element [(3)] having generally opposed first and second surfaces [(5, 30)], feed means [(4)] for supplying at least one reactant [(15)] to the first surface [(5)] of the support element[(3)], collector means [(32)] for collecting product from the first surface [(5)] of the support element [(3)] and means [(34)] for applying a heat transfer fluid [(35)] to the second surface[(30)], characterised in that the second surface [(30)] includes an axially located undercut trough [(33)] into which the heat transfer fluid [(35)] is supplied during operation of the reactor.

11.(Amended) A reactor as claimed in [any preceding] claim 1, wherein there is further provided a rotary impeller or fan [(70)] mounted close to the first surface [(5, 19)] and operable to generate a gaseous flow from a periphery of the surface [(5, 19)] towards a central region thereof, this flow being counter-current to a flow of reactant [(15)] on the first surface[(5, 19)].

12.(New) A reactor as claimed in claim 9, wherein there is further provided a rotary impeller or fan mounted close to the first surface and operable to generate a gaseous flow from a periphery of the surface towards a central region thereof, this flow being counter-current to a flow of reactant on the first surface.

13.(New) A reactor as claimed in claim 10, wherein there is further provided a rotary impeller or fan mounted close to the first surface and operable to generate a gaseous flow from a periphery of the surface towards a central region thereof, this flow being counter-current to a flow of reactant on the first surface.

GB 000000526

ROTATING SURFACE OF REVOLUTION REACTOR WITH TEMPERATURE CONTROL MECHANISMS

The present invention relates to a rotating surface of revolution reactor provided with various temperature control mechanisms.

The invention makes use of rotating surfaces of revolution technology (hereinafter RSORT) (commonly known as spinning disc technology).

The spinning disc concept is an attempt to apply process intensification methods within the fields of heat and mass transfer. The technology operates by the use of high gravity fields created by rotation of a disc surface causing fluid introduced to the dire surface at its axis to flow radially outward under the influence of centrifugal acccleration in the form of thin often wavy films. Such thin films have been shown to significantly improve the heat and mass transfer rates and mixing. The technology was developed for typical heat and mass transfer operations such as heat exchanging, heating, cooling and mixing, blending and the like, for example as disclosed in R J J Jachuck and C Ramshaw, "Process Intensification: Heat transfer characteristics of tailored rotating surfaces", Heat Recovery Systems & CHP, Vol. 14, No 5, p475-491, 1994.

More recently the technology has been adapted for use as a reacting surface for systems which are heat and mass transfer limited, for example for the reaction of substrates which are highly viscous during at least a stage of the reaction and cause problems in achieving good mixing and product yields.

Boodhoo, Jachuck & Ramshaw disclose in "Process Intensification: Spinning Disc Polymeriser for the Manufacture of Polystyrene" the use of a spinning disc apparatus in which monomer and initiator is reacted by conventional means to provide a pre-polymer which is then passed across the surface of a spinning disc at elevated temperature providing a conversion product in the form of polymerised styrene.

EP 0 499 363 (Tioxide Group Services Limited) discloses another use for spinning disc technology in photo catalytic degradation of organic materials such a hydrocarbons. A solution of salicylic acid and titanium dioxide catalyst was passed across the surface of a rotating disc and irradiated with ultra violet light.

These publications therefore disclose the use of spinning disc technology for heating and mass transfer in inert and reactive systems.

GB 9903474.6 (University of Newcastle), from which the present application claims priority and the disclosure of which is hereby incorporated into the present application by reference, describes the use of RSORT in the conversion of a fluid phase substrate by dynamic heterogeneous contact with an agent. In this application, it is described how it has surprisingly been found that spinning disc technology may be further adapted to apply process intensification methods not only within the fields of heat and mass transfer but also within the field of heterogeneous contacting. Furthermore, it is described how it has surprisingly been found that the quality of the product obtained is of higher quality than that obtained by conventional processing having, for example, a higher purity or, in polymers, a narrower molecular distribution.

In addition to this, spinning disc technology can be used to obtain products not readily obtainable by other technology.

According to a first aspect of the present invention, there is provided a reactor apparatus including a hollow support element adapted to be rotatable about an axis, the support element having a first, external reaction surface and a second, internal heat transfer surface and means for applying a heat transfer fluid to the second surface, the first and second surfaces being in thermal communication with each other and the support element including an internal space bounded on one side by the second surface, characterised in that a plate or membrane is provided inside the hollow support element, the plate or membrane extending substantially over the whole internal space so as to define a first space between the second surface and one side of the plate or membrane and a second space between an opposed side of the plate or membrane and an internal surface of the support element remote from the second surface, but leaving a gap at a periphery of the plate or membrane so as to allow a heat transfer fluid to flow between the first and second spaces.

According to a second aspect of the present invention, there is provided a reactor apparatus including a support element adapted to be rotatable about an axis, the support element having generally opposed first and second surfaces, feed means for supplying at least one reactant to the first surface of the support element, collector means for collecting product from the first surface of the support element and means

for applying a heat transfer fluid to the second surface, characterised in that the support element has a generally circular outer perimeter provided with a groove or indent thereabout and a circumferential baffle is fitted about the perimeter of the support element so as to project into the groove or indent while still allowing the support element to rotate freely, the circumferential baffle serving to keep separate reactant and heat transfer fluid which are thrown respectively from the first and second surfaces during operation of the reactor.

According to a third aspect of the present invention, there is provided a reactor apparatus including a support element adapted to be rotatable about an axis, the support element having generally opposed first and second surfaces, feed means for supplying at least one reactant to the first surface of the support element, collector means for collecting product from the first surface of the support element and means for applying a heat transfer fluid to the second surface, characterised in that the second surface includes an axially located undercut trough into which the heat transfer fluid is supplied during operation of the reactor.

It is to be understood that the term "reactant" is not limited to substances which are intended to undergo chemical reaction on the first surface of the support element, but also includes substances which are intended to undergo physical or other processes such as mixing or heating. Similarly, the term "product" is intended to denote the substance or substances which are collected from the first surface of the support element, whether these have undergone chemical or physical processing or both. In addition, although it is envisaged that most reactants and products will be in the liquid phase, the apparatus can be used with any suitable fluid phase reactants and products, including combinations of liquid, solid and gaseous reactants and products. For example, solid phase substances in substantially free-flowing particulate form can have macroscopic fluid flow properties.

An RSORT apparatus (commonly known as a spinning disc reactor) generally includes within a conversion chamber a rotating surface or an assembly of a plurality of these which is rotated about an axis to effect transfer of one or more reactants from the axis preferably radially across the rotating surface.

An RSORT apparatus as hereinbefore defined comprising a rotating surface as hereinbefore defined has a number of advantageous constructional features according to the present invention.